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VALIDATING AND DISSEMINATING THE PRESENCE OF MICRO-NUTRIENTS IN HEMP FOOD COMMODITIES

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Project report

Validating and Disseminating the Presence of MicroNutrients in Hemp Food Commodities

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Project #: 20040612

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Summary

This project is a key element of the ongoing comprehensive nutritional characterization of hemp seeds and the main food commodities produced from them. Research involved the acquisition of raw materials (hemp seeds, shelled hemp seeds and seed cake) for the four main hemp varieties commercially grown in Canada and one emerging variety. Samples were analyzed at the University of Lethbridge, Department of Chemistry and Biochemistry, for the following parameters, which are of main importance for a nutritional assessment of hemp seeds and products:

- Composition of fatty acid spectrum,
- Tocopherols (Vitamin E Complex)
- Select minerals (phosphorus, calcium, potassium, magnesium, manganese, sodium, iron, and zinc
- Select Vitamins (Thiamin (B_1), Riboflavin (B_2), Niacin (B3); Pantothenic Acid; Pyridoxine (B_6); Folic Acid (Folate); Vitamin A
- Phytosterols, Flavonoids and Lignans.

The present research yielded the following key results:

- All hemp varieties produce a fatty acid spectrum with significant proportions of the nutritionally important omega-3 fatty acids alpha-linolenic and stearidonic acid, as well as the "higher" omega-6 fatty acid gamma linolenic acid. Proportions are somewhat variety specific.
- Hemp oil is a good source of tocopherols. The gamma isomer by far dominates with some variation of tocopherol levels between varieties.
- Hemp seeds are very good sources of several minerals, i.e. phosphorus, magnesium, manganese and iron and good sources of potassium and zinc. Hemp seeds are also good sources of Vitamin B1 and of Folic acid. Variation among varieties is limited.
- Hemp seeds are also good sources of several phytosterols. They are minor sources of flavonoids and lignans.
- A preliminary comparison with the nutritional characteristics of other nuts and oilseeds, combined with the results of a recently completed evaluation of hemp protein at the University of Manitoba suggests that hemp seeds have a very attractive and competitive nutritional composition, which is in line with several current trends in human nutrition. The results from this and the concurrent studies will be used by the North American hemp industry to promote the nutritional benefits of hemp foods.

Introduction

This present project is a key component in a comprehensive research and market development program currently conducted by the Canadian Hemp Trade Alliance (CHTA) on behalf of the North American hemp foods industry. That industry includes Canadian growers and processors of hemp grain and manufacturers and distributors of hemp food products in Canada and the U.S. This program's overall objective is to sustain the current growth of the industry – about 40-50% per year - by establishing and effectively disseminating science-based information on the nutritional attributes and potential benefits of hemp grain and its derivatives. Since commercial hemp farming remains illegal in the U.S., virtually all hemp foods sold in the U.S. originate from Canada.

In the past, several studies have characterized individual elements of hemp grain's nutritional profile, both in Canada and the EU. Yet, there are no publications in the scientific literature, written by reputable nutritional scientists, who have provided a comprehensive overview of the nutritional attributes of hemp grain and an assessment of the related potential health benefits. Such a publication is now needed by the industry and its associations for more effective, health and nutrition based marketing. Also, since hemp cultivars and growing conditions (latitude) in Canada appear to produce a more favorable fatty acid spectrum, particularly compared to Chinese hemp seeds – a main emerging competitor in the U.S. market – this work would also help document potential competitive advantages.

The present project was aimed at establishing the composition of hemp grain grown in Canada and its derivatives re. their fatty acid profiles, minerals, vitamins, phytochemicals and antinutrients. It is a modular addition to an assessment of the nutritional value of hemp protein, recently completed at the University of Manitoba, Winnipeg. Based on the results from both studies, the investigators of both studies will now prepare a publication in a peer-reviewed journal. Other activities will include the production of a brochure on hemp and nutrition, similar to what the canola, flax or walnut industries have done.

Project Scope

The analytical work of this project was conducted at the University of Lethbridge, Department of Chemistry and Biochemistry. It involved the nutritional assessment of lipid components, minerals, vitamins and flavonoids present in the four key hemp grain-derived commodities, i.e. whole hemp seeds, shelled seeds (nuts), hemp oil and hemp protein flour. A total of 17 samples were analyzed. They cover the four dominant hemp varieties grown in Canada (Finola, USO-14, USO-31, Crag) and Alyssia, a new variety under development. Table 1 lists the samples under evaluation.

Analyses were performed to establish composition of fatty acids, tocopherols (Vitamin E complex) and sterols in hemp seed oil. In addition, hemp seeds and nuts were analyzed for their content of minerals, vitamins, lignans and flavonoids. This report summarizes and displays the results. Data are presented as graphs showing the classes of components detected and quantified in hemp seeds and hemp products. For each group of components, a brief discussion summarizes significance and potential health effects of the observed composition.

Table 1

Sample List for Study
Validating and Disseminating the Presence of MicroNutrients in Hemp Food Commodities

Matrix	Whole seed	Whole seed	Protein Flour	Whole seed	Whole seed	Hemp flour	Hemp nut	Whole seed	Whole seed	Hemp nut
Source	HOC House	Hemp Oil Canada	Hemp Oil Canada	Manitoba Harvest	Manitoba Harvest	Manitoba Harvest	Manitoba Harvest	HOC House, subs.	Hemp Oil Canada	Hemp Oil Canada
Variety	Finola	Finola	Finola	USO-14	USO-14	USO-14	USO-14	USO-31	USO-31	USO-31
Crop Year	2003, MB	2004, MB	2004, MB	2003	2004	2003	2003	2003	2004, MB	2004, MB
Sample Code	HSC	HS5a	HPF4a	HS4	HS2	HPF3	HN4	HS2	HS1	HN1a

Matrix	Whole seed	Whole seed	Hemp flour	Hemp flour	Hemp nut	Hemp nut fines	Whole seed
Source	Garry Meer	Hemp Oil Canada	Nutiva	Hemp Oil Canada	Hemp Oil Canada	Hemp Oil Canada	Kelln Watson
Variety	Crag	Crag	Crag	Crag	Crag	Crag	Alyssa
Crop Year	2003	2004	2004, SI	2004, MB	2004, MB	2004, MB	2004
Sample Code	HS6	HS7a	HPF6	HPF5a	HN5	HN7	HS9

Results and Discussion

Fatty Acids

Analyzed fatty acids included positional isomers in all samples of hemp seed, hemp nut and flour. Data for the group of nutritionally important fatty acids, analyzed in different hemp varieties are shown in Figures 1 and 2. Among all varieties USO-31 contained the lowest amount of polyunsaturated fatty acids (PUFA) and a higher contribution of monounsaturated fatty acids (MUFA). For all varieties the amount of saturated fatty acids (SAT) were at the lower end compared to other vegetable oils, below 10%, except USO-31 which exceed this level. Hemp seed oils showed typical composition of individual fatty acids, however differences were observed in the contribution of the nutritionally important gamma linolenic, alpha linolenic and stearidonic acids (Fig 2). The variety Finola, crop year 2004, showed the highest contribution of GLA and stearidonic, whereas, USO-31 the lowest among varieties analyzed. Also USO-31 offered the lowest amount of total omega-3 fatty acids. Omega-3, particularly stearidonic acid can have positive effects on blood cholesterol, help ameliorate certain cardiovascular diseases and may affect the risk of inflammatory diseases. Generally, our diet is deficient in omega-3 fatty acids causing health problems related to overload with omega-6 acids. Crag contained the highest amount of omega-3 fatty acids among all varieties analyzed. However it had slightly lower contribution of stearidonic acid but the highest amount of alpha linolenic acid.

Fatty acid composition of hemp products followed patterns of varieties from which they were produced (Fig 3 and 4).

Tocopherols

These compounds are the main natural antioxidants in vegetable oil. Tocopherols are potent antioxidants, protecting our body from oxidative damage and helping with oxidative stress by quenching radicals. Hemp oils contain mainly the gamma isomer of tocopherol with lower amounts of the alpha isomer (Fig 5). The latter is generally counted as vitamin E. However, recent work showed that the other tocoopherol isomers offer benefits similar to that of alpha tocopherol, but with different activity. Gamma and delta isomers of tocopherols have been shown to have comparable activity as alpha isomer in protecting our body against oxidative stress. Small amounts of beta isomer were detected in all hemp varieties. Both USO varieties showed the lowest total amounts of tocopherols, while Crag the highest (Fig 5, last two bars to the right). Since tocopherols are fat soluble, concentration of tocopherols in seed follow those in the oil, with the highest amounts in the varieties Finola and Crag. Amount of tocopherols in seed is affected by the content of these components in oil and the amount of oil in seed.

Phytosterols

A variety of plant sterols were detected in hemp oil, with the greatest contribution of beta sitosterol (Fig 6). This sterol is the most common in almost all plant origin material. Second in the amount was campesterol followed by stigmasterol. This pattern is similar to that found in soybean oil. Brassicasterol and avenasterol were only found in small amounts. Brassicasterol is typical for plants from the Cruciferae family, such as mustard, cabbage, and rapeseed. Plant sterols are known for their beneficial effect on blood cholesterol because they compete with cholesterol during absorption in the digestive tract, thus suppressing absorption of the latter. Recent research showed that sterols in oils have the same effectiveness as the sterol alcohols added to some foods. USO-31 showed the

lowest amount of sterols (Fig 6). Total amounts of sterols in hemp varieties showed similar pattern as individual sterols, with the lowest amounts in USO-31 and the highest in Finola (Fig 7). The amount of phytosterols in hemp products followed the pattern of the variety from which they were produced (Fig 8). Higher amounts of sterols in seeds are related to the amount of oil present in particular seed and products (Fig 9).

Vitamins

Hemp seeds were analyzed for the following vitamins: Thiamin (B_1), Riboflavin (B_2), Niacin (Nicotinic acid; niacin can be produced in our body from tryptophan); Pantothenic Acid; Pyridoxine (B_6); Folic Acid (Folate); Vitamin A (analyzed as it provitamin - beta carotene). Data for all vitamins analyzed in the hemp seed varieties studied are presented in Fig 10. Pantothenic acid and niacin in all samples were at the highest amounts comparing to other vitamins. Folic acid was third in the amount present of varietal hemp seed samples. Similar patterns were observed for pantothenic and folic acids in selected hemp flour and nut samples (Fig 11). Increased amounts were observed in flour as compared to whole seed, this is related to the removal of oil, which naturally contains minimal amounts of B-Vitamins.

The precursor of vitamin A, beta-carotene, was found at levels of only a few ppm in seeds (Fig 17). The dominant pigment detected in analyzed hemp seeds was chlorophyll.

Minerals

Hemp seed products were analyzed for the following minerals: Calcium, Magnesium, Potassium, Phosphorus, Sodium, Iron, Manganese and Zinc. Concentrations of the first four minerals are shown in Fig 12. Phosphorus was the dominant mineral in all hemp samples followed by potassium. The latter is a typical mineral in the intracellular liquids of plant cell. The third most prevalent mineral was magnesium, a typical component of chlorophyll, although cell liquids also contain it. The concentration of calcium, the fourth most common mineral in hemp seed was relatively high. Compared to other nuts and oil seeds, all four elements were present at high levels. The other four minerals, namely sodium, iron, manganese and zinc, were found in concentrations below 150 ppm, compared to the other four minerals, all of which were found at levels above 1000 ppm (Fig 13 and Fig 12, respectively). Iron was the dominant among those minerals followed by manganese and zinc. It worth to notice the amounts of sodium were the lowest among all minerals assessed. Typically sodium is not the dominant mineral in plant material. A similar pattern of minerals were observed in hemp products (Fig 14 and 15).

Flavonoids and Lignans

Both groups of compounds are phenolic compounds, most of which have potent health effect as nutraceuticals and antioxidants. The concentrations of flavonoids and lignans in hemp samples were rather small in terms of the potential dose they may provide from a nutraceutical point of view (Fig 16). Amount of lignans assessed was at level similar to many plant origin products, usually below 50 ppm. The concentrations of flavonoids were typically twice that of lignans (Fig 16).

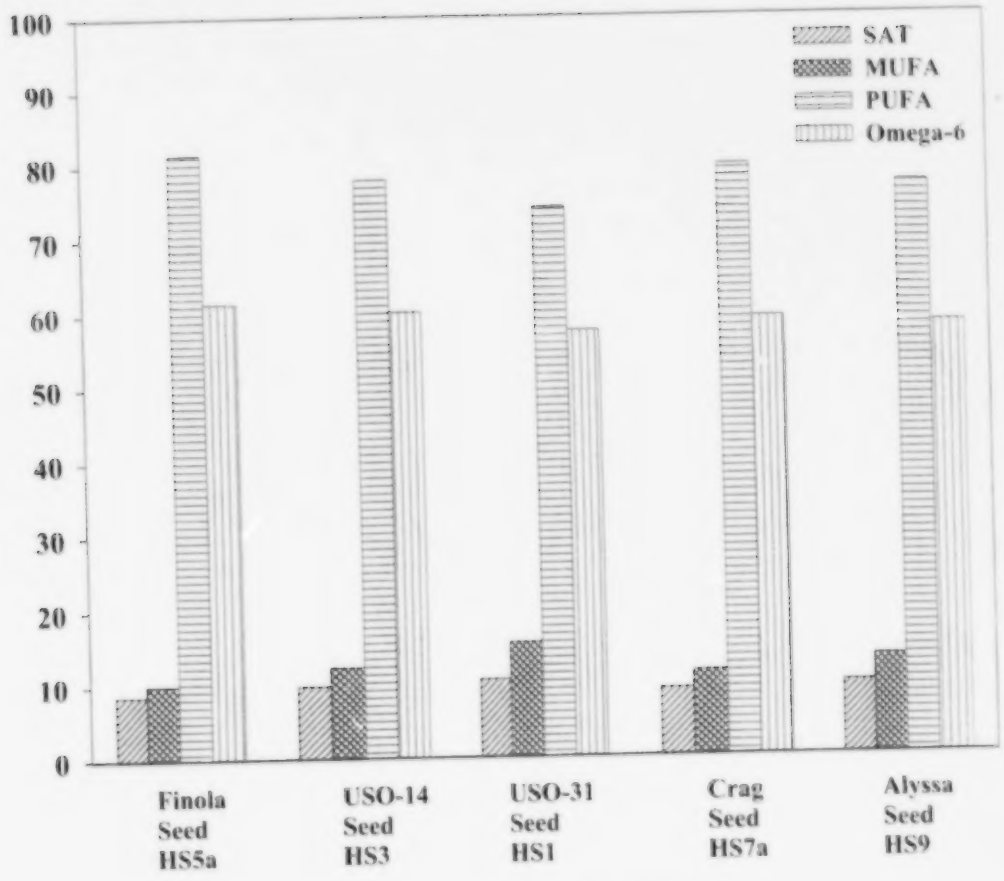

Fig 1. Contribution of fatty acids groups in oils from different hemp seeds varieties 2004 crop.

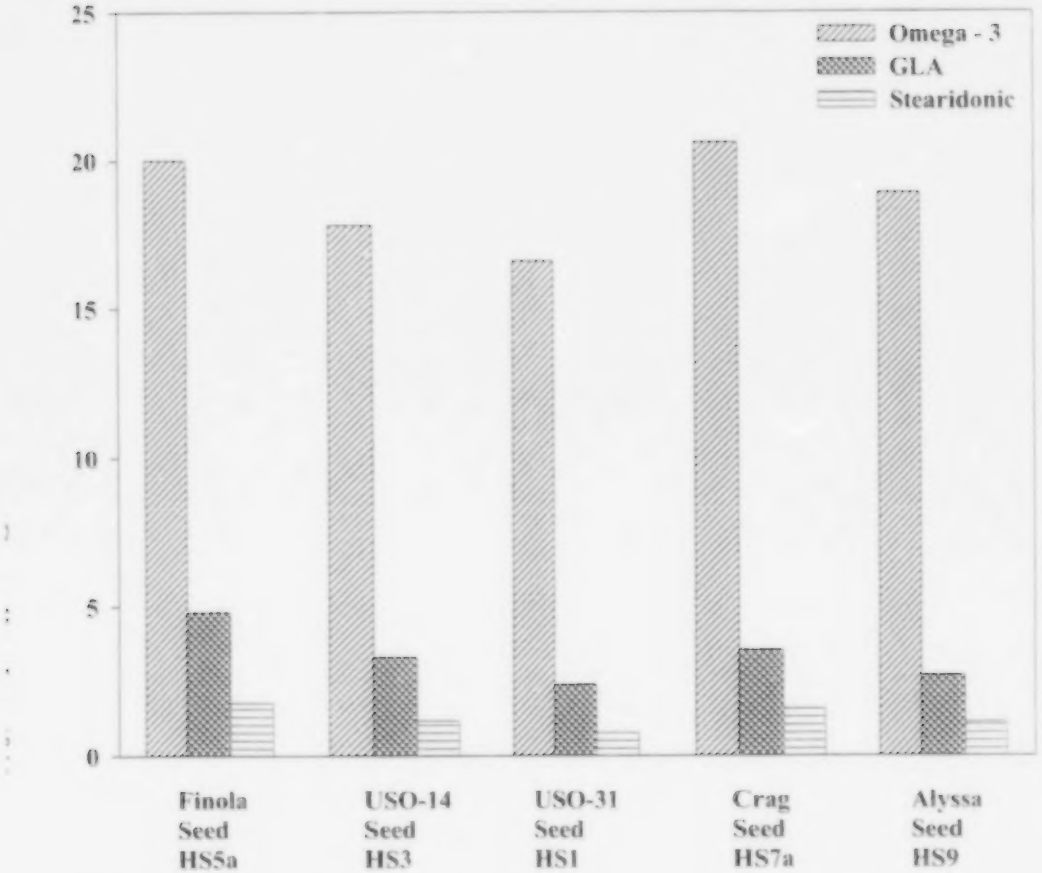

Fig 2. Contribution of special fatty acids in oils from different varieties of hemp seeds, 2004 crop.

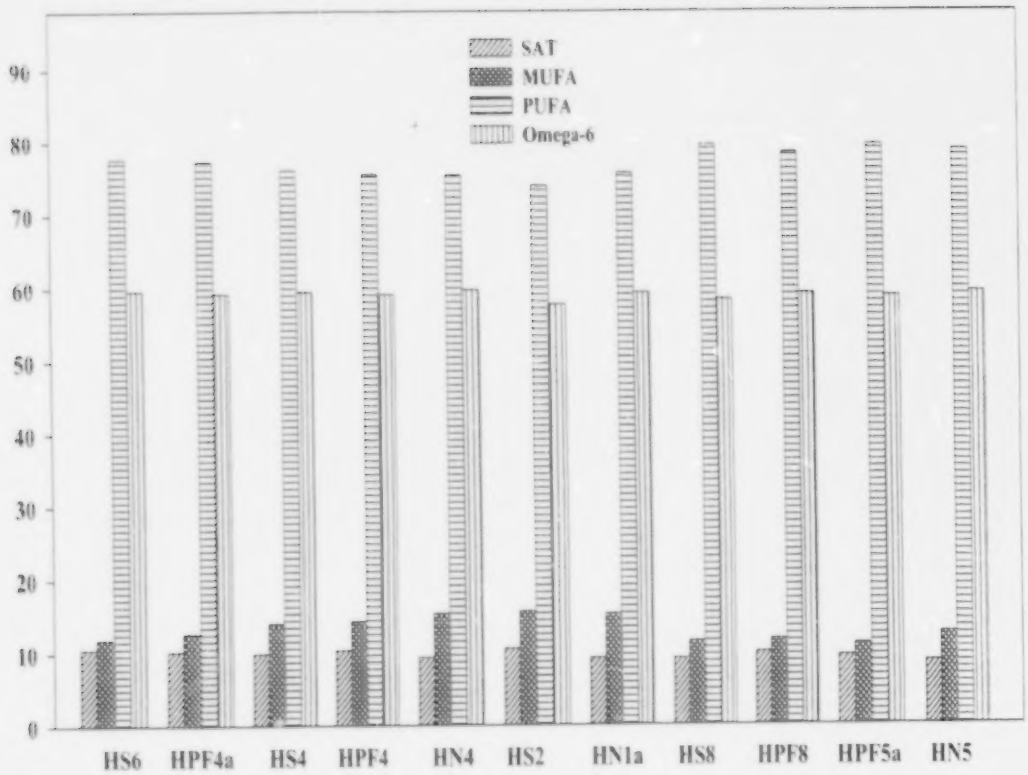

Fig 3. Groups of fatty acids present in oils from different hemp seed samples. Sample Description: HS6 - Finola Seed 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Nut; HN4 - USO-14 Seed 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004

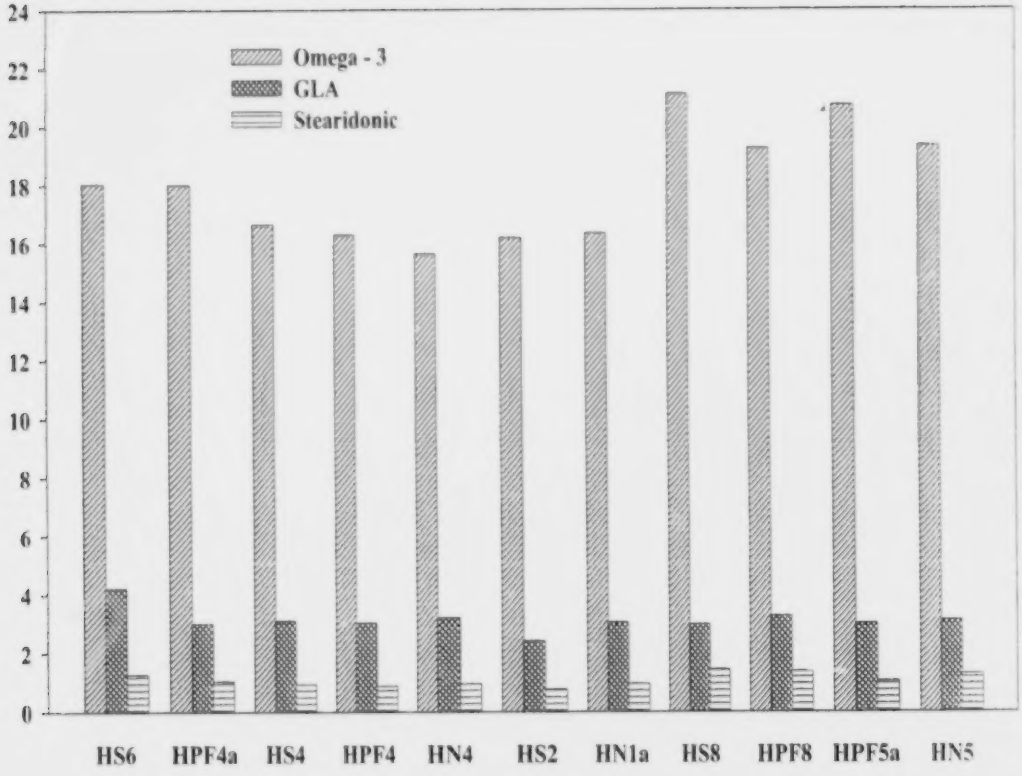

Fig 4. Specific fatty acids present in oils from different hemp seed samples. Sample Description: HS6 - Finola Seed 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004.

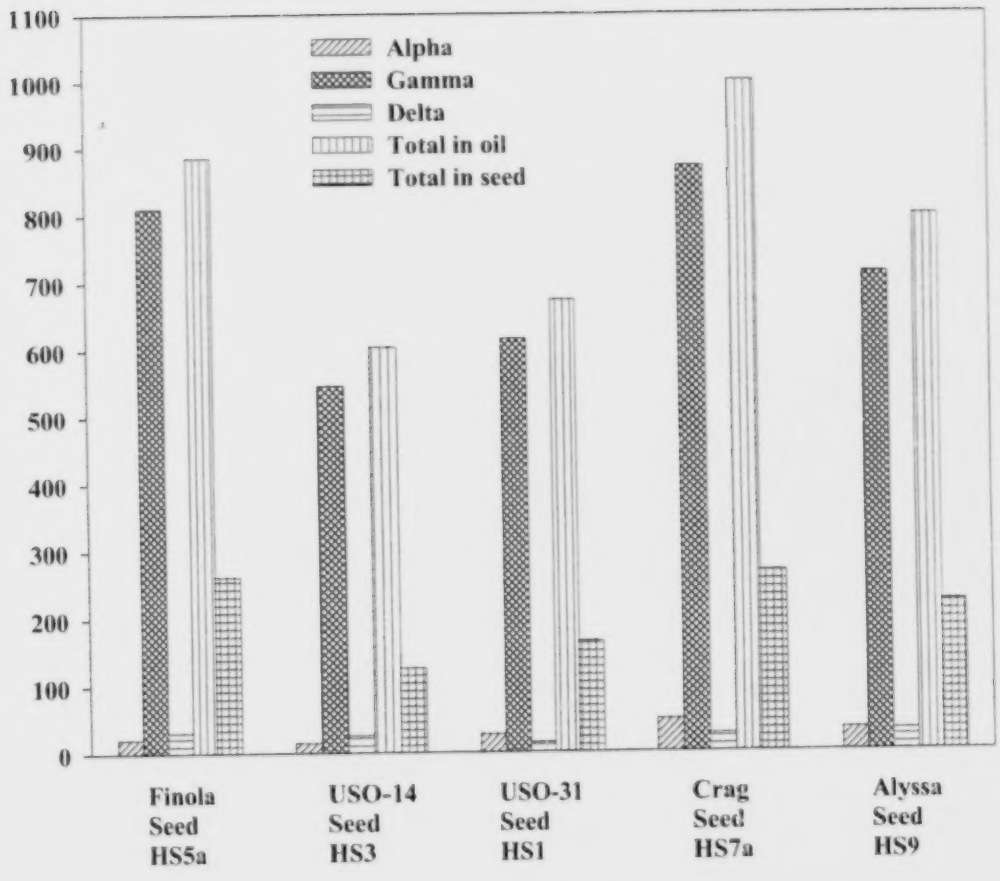

Fig 5. Tocopherols in oils from different hemp seeds varieties, 2004 crop.

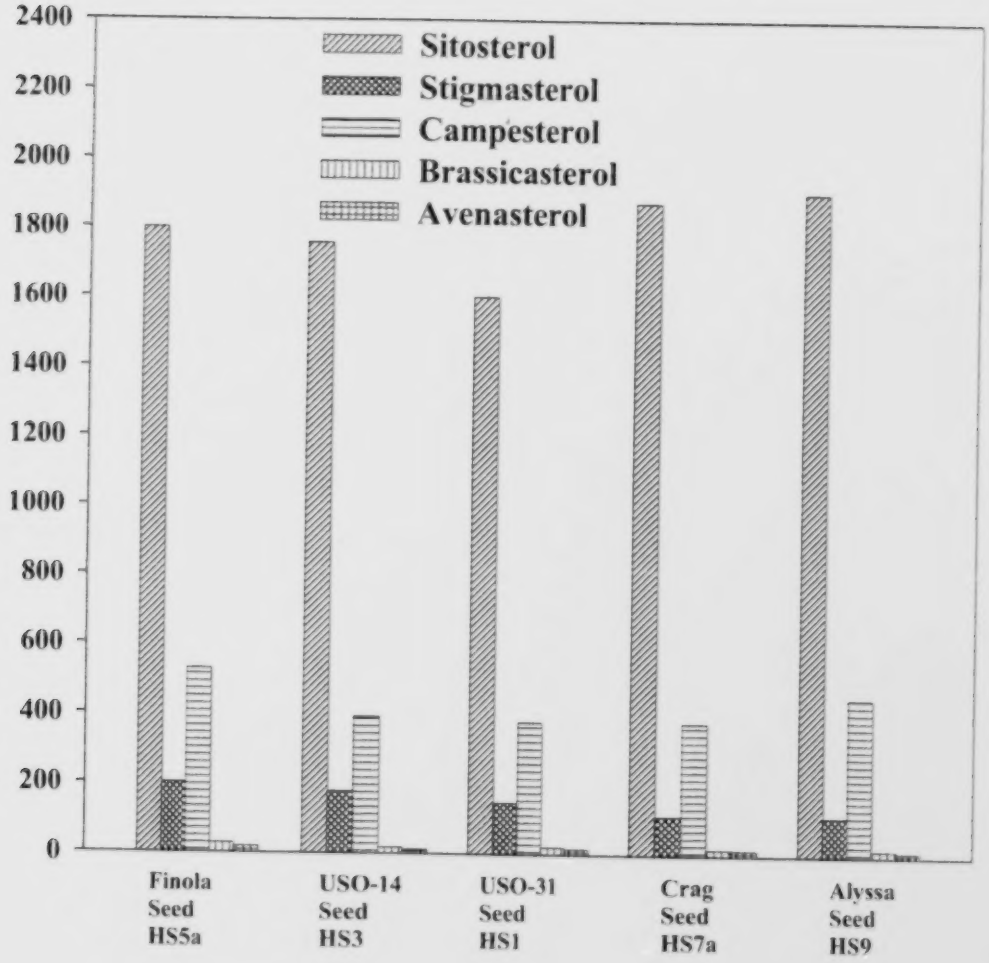

Fig 6. Composition of plant sterols in oil from different hemp varieties, crop 2004.

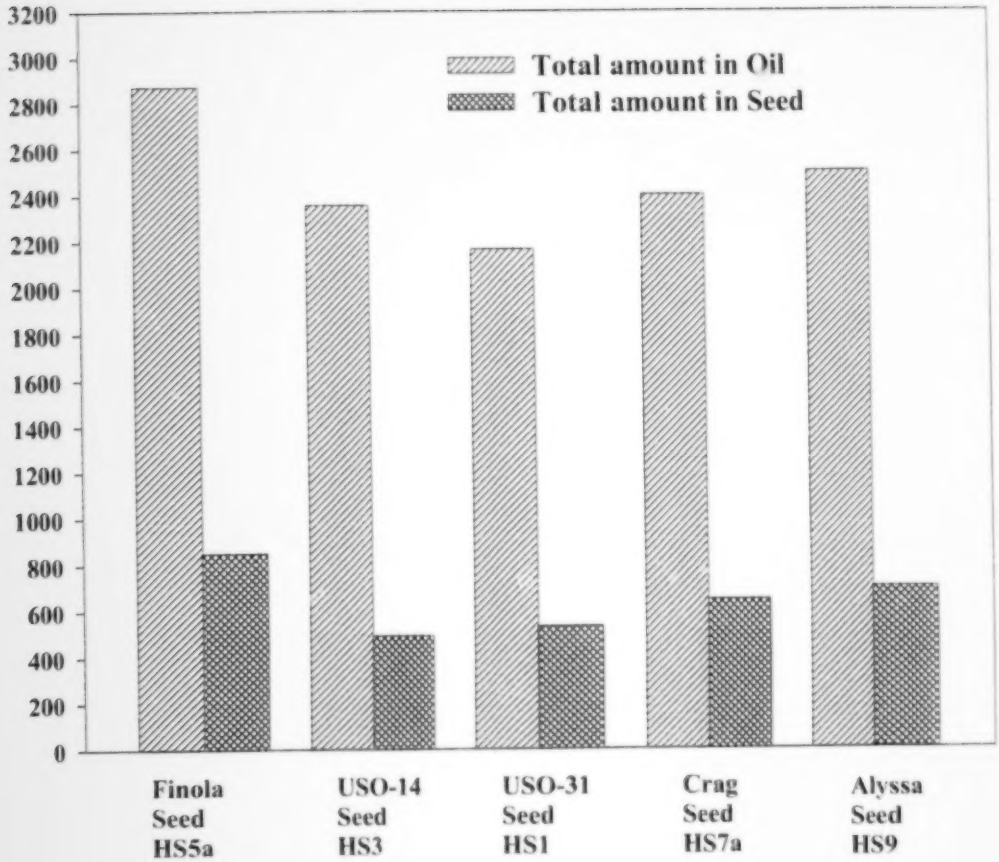

Fig 7. Total amounts of phytosterols in oils and seeds from different varieties of hemp, crop 2004

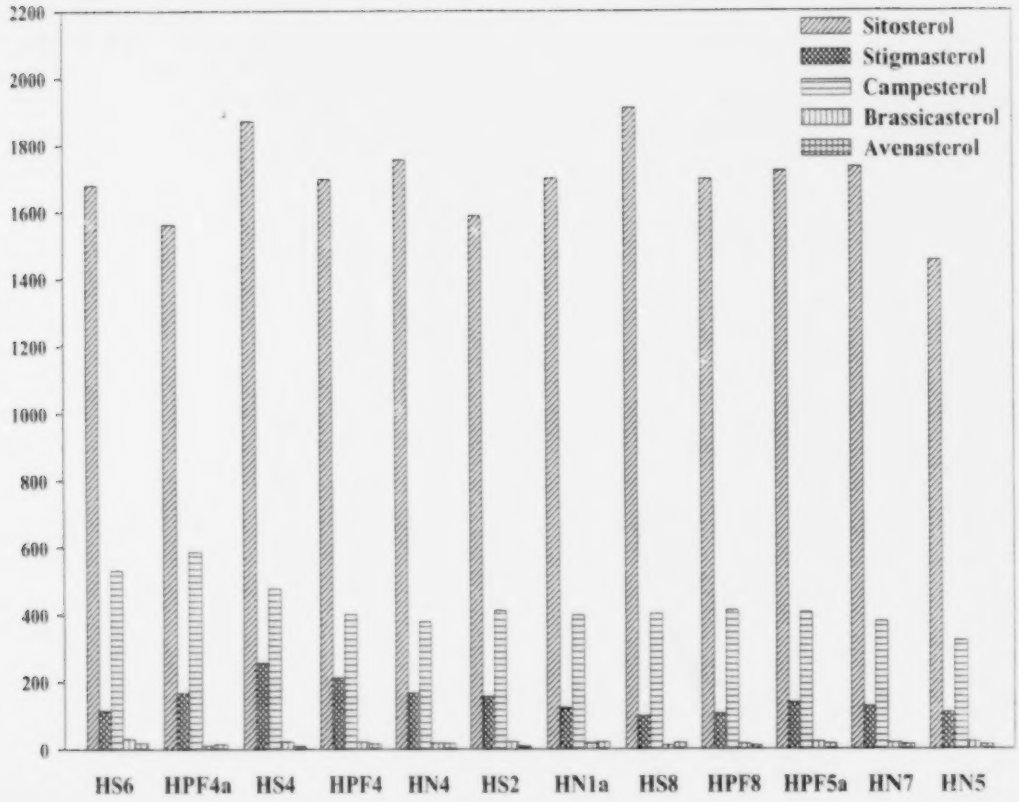

Fig 8. Composition of phytosterols in oils from different hemp seed samples. Sample Description: HS6 - Finola Seed 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004.

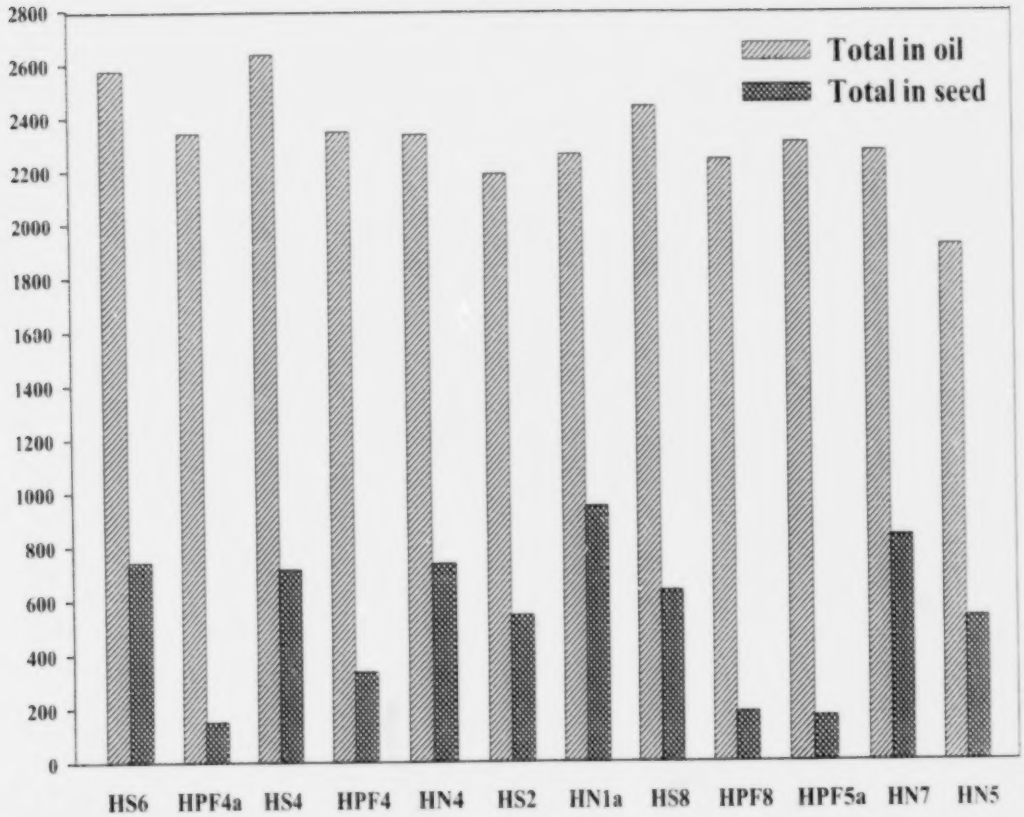

Fig 9. Total amounts of phytosterols in oils from different hemp seed samples. Sample Description: HS6 - Finola Seed 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004.

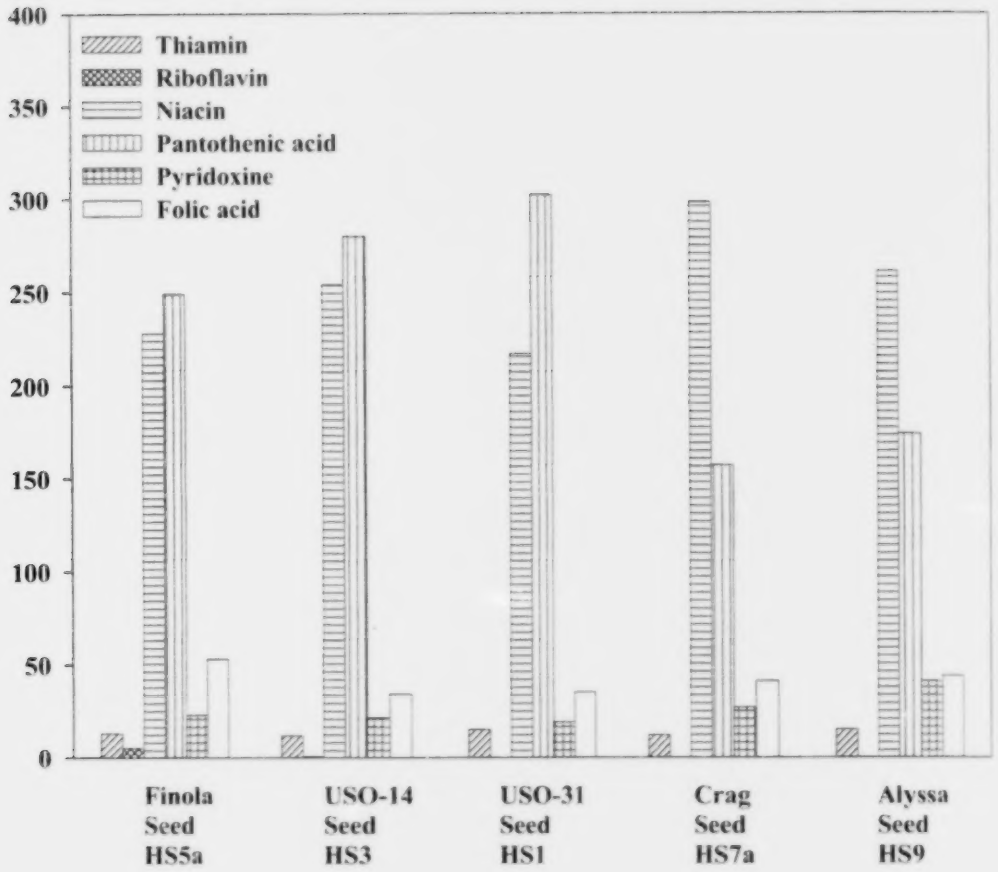

Fig 10. Vitamins presence in different hemp seeds varieties, 2004 crop .

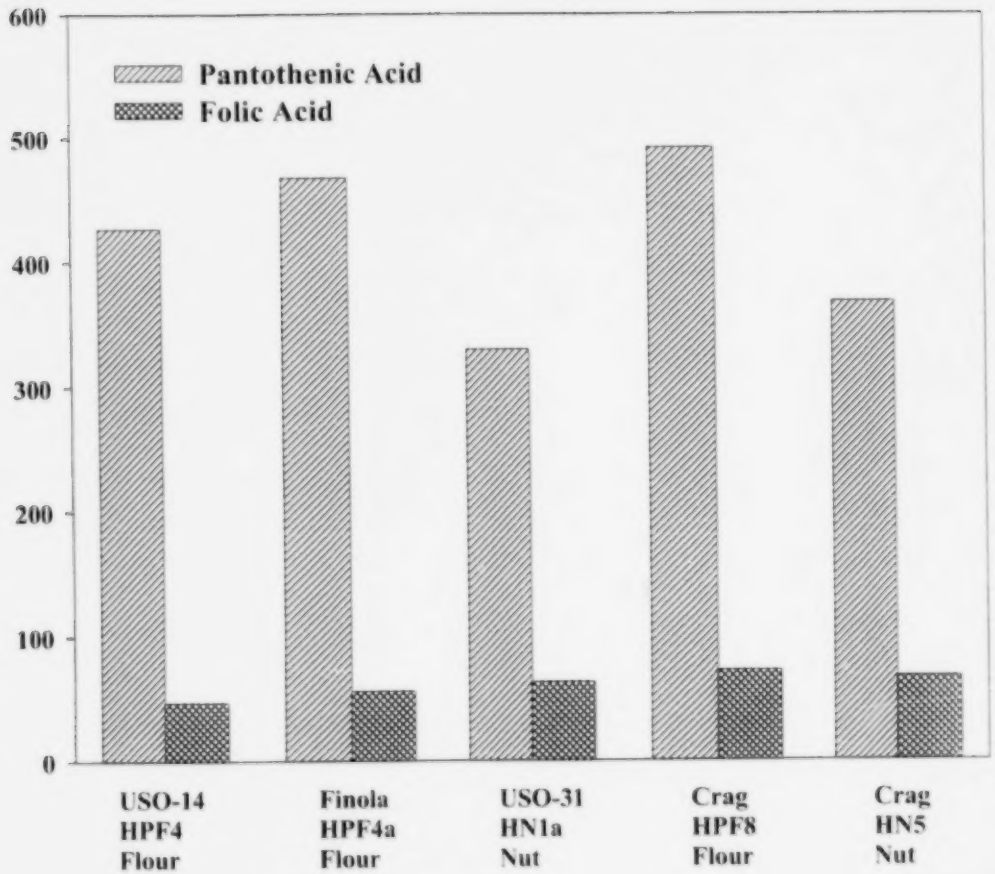

Fig 11. Selected vitamins content in hemp seed flour and nut, 2004 crop.

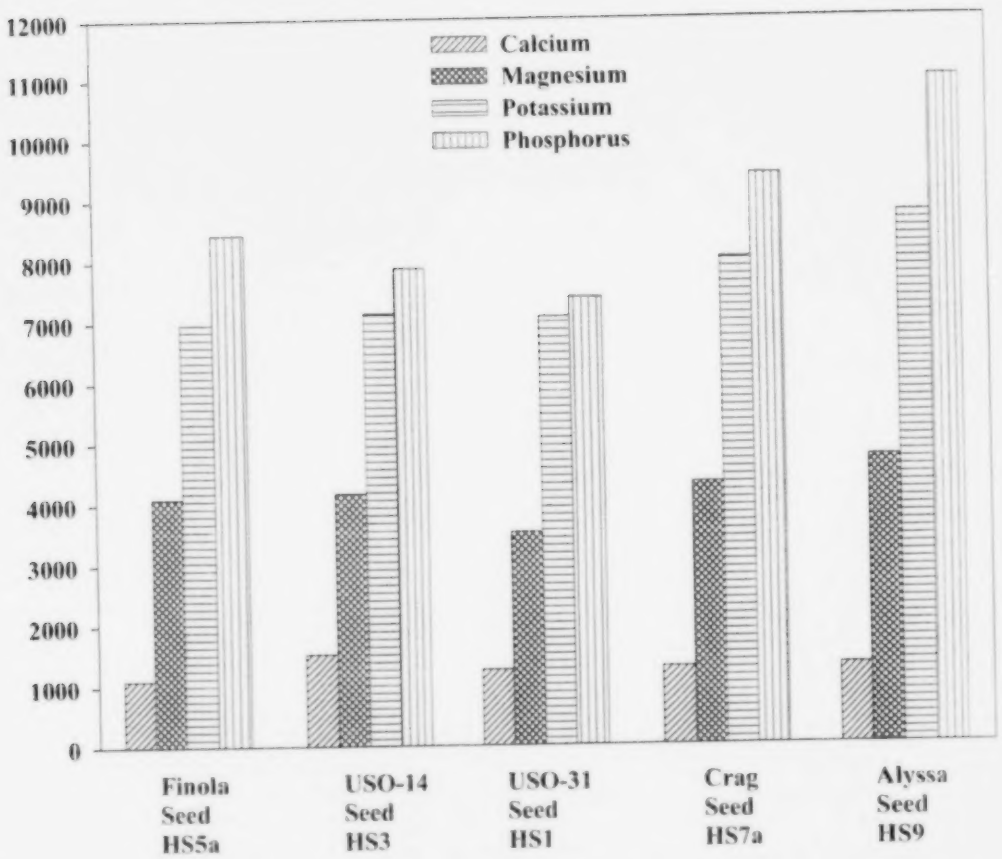

Fig 12. Presence of minerals in different hemp seed varieties, 2004 drop.

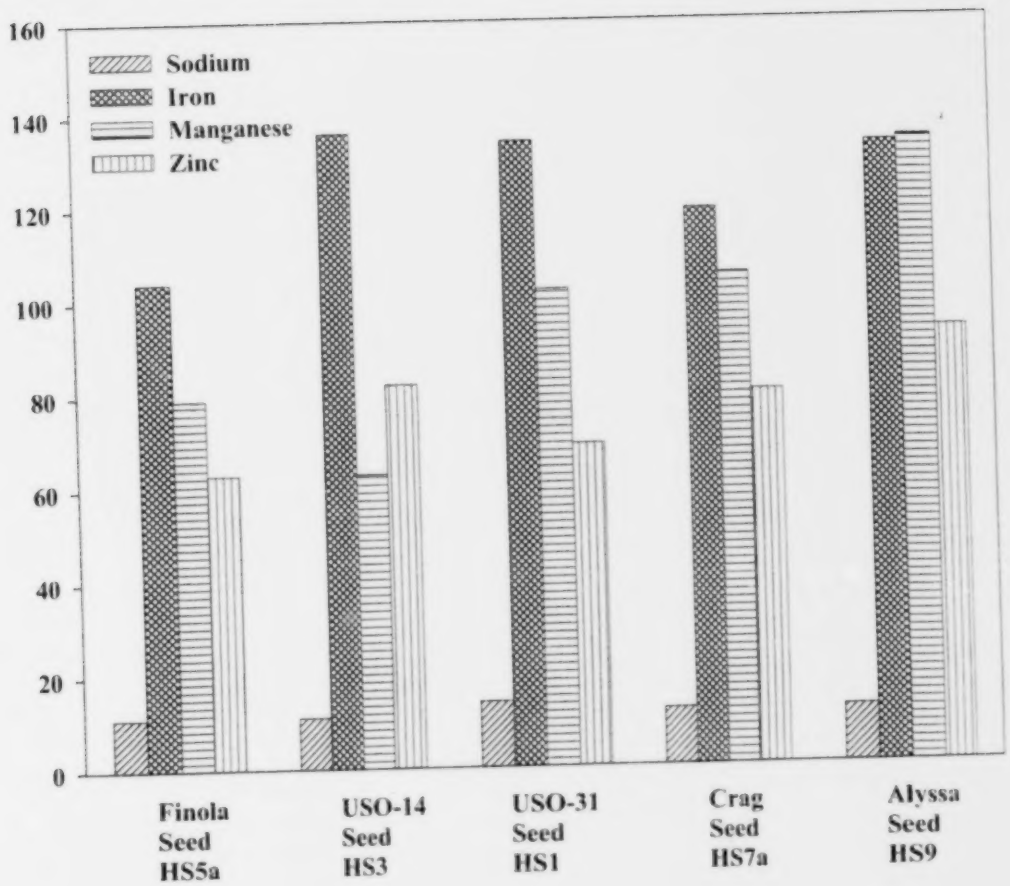

Fig 13. Presence of specific minerals in different hemp seed varieties, 2004 crop.

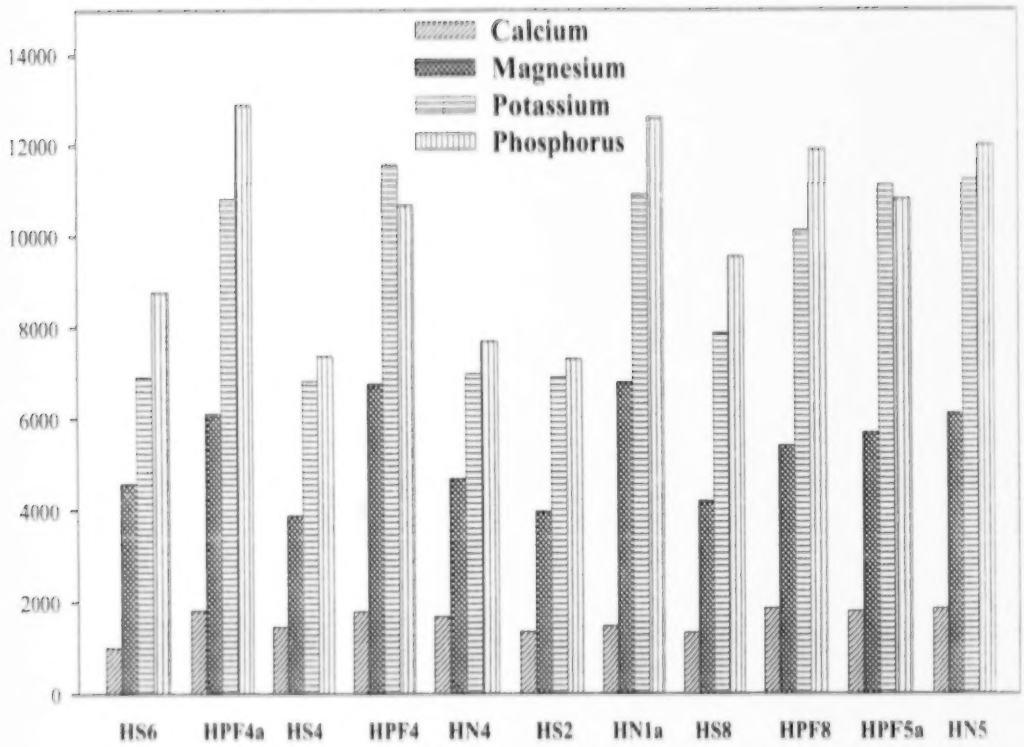

Fig 14. Composition of minerals in different hemp seed samples. Sample Description: HS6 - Seed Finola 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004.

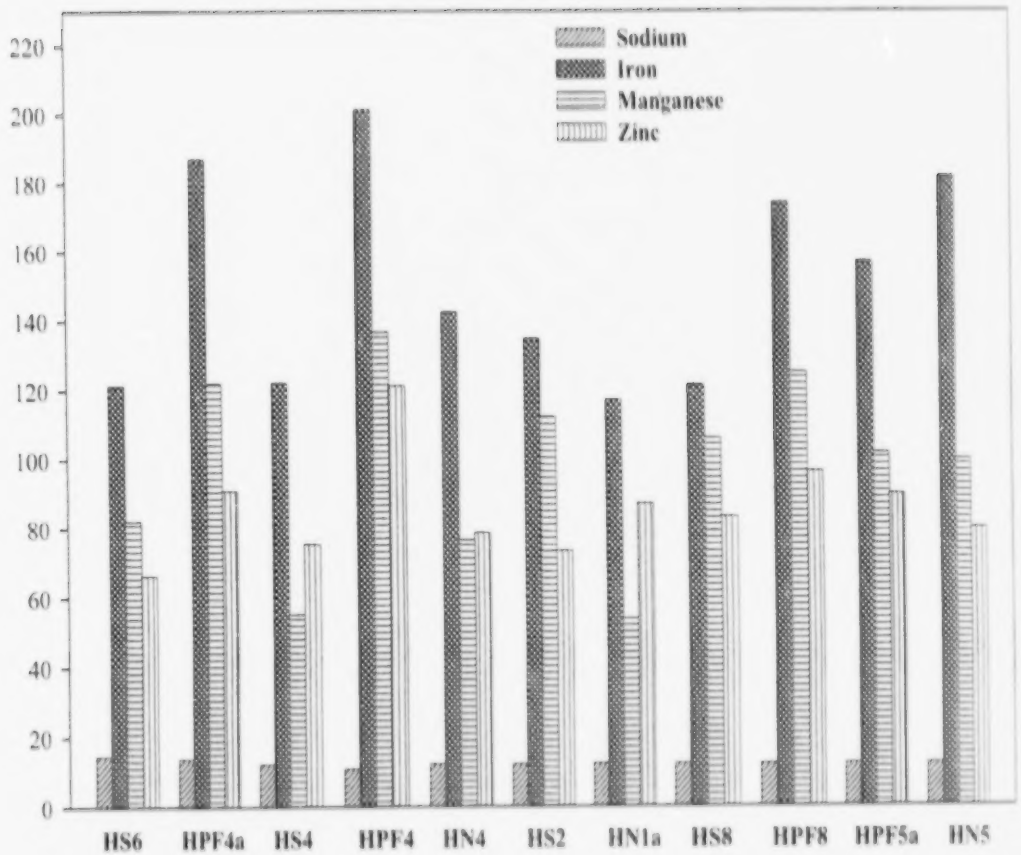

Fig 15. Specific minerals in different hemp seed samples. Sample Description: HS6 - Seed Finola 2003; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004.

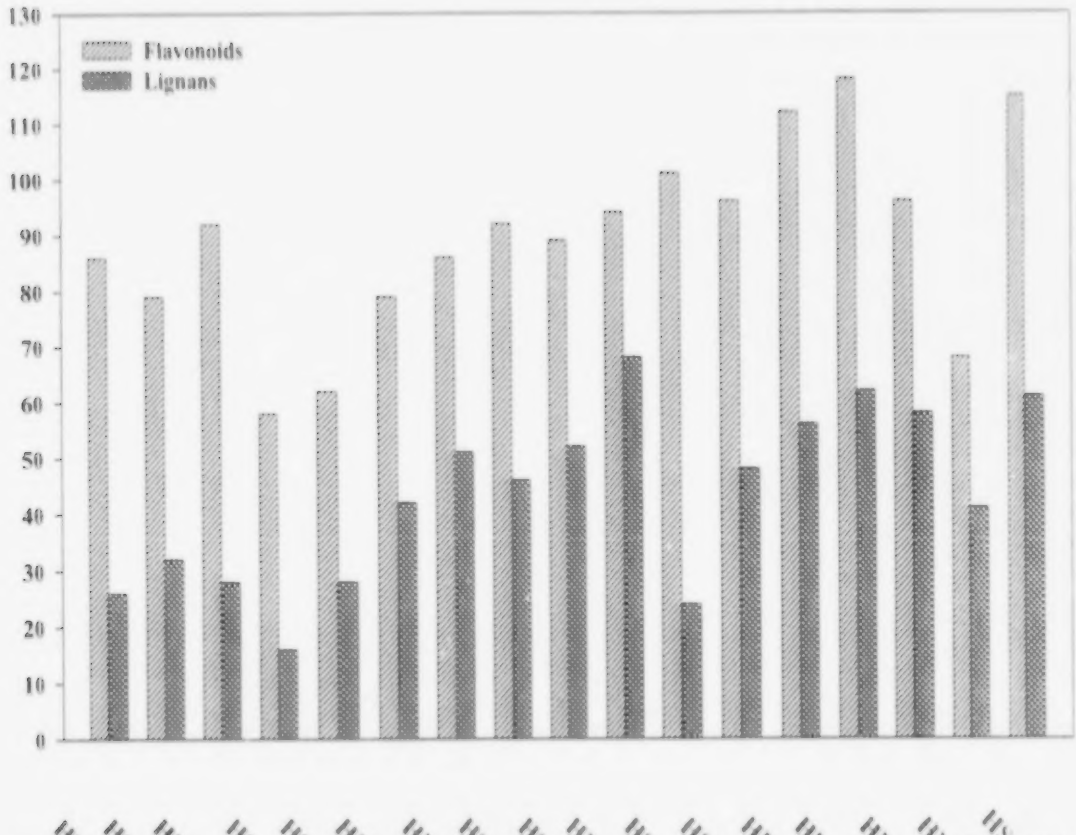

Fig 10. Presence of flavonoids and lignans in different hemp seed samples. Sample Description: HS6 - Seed Finola 2003; HS5a - Finola Seed 2004; HPF4a - Finola Flour 2004; HS4 - USO-14 Seed 2003; HS3 - USO-14 Seed 2004; HPF4 - USO-14 Flour; HN4 - USO-14 Nut 2003; HS2 - USO-31 - Seed 2003; HS1 - USO-31 Seed 2004; HN1a - USO-31 Nut 2004; HS8 - Crag Seed 2003; HS7a - Crag Seed 2004; HPF8 - Crag Flour 2004; HPF5a - Crag Flour 2003; HN5 - Crag Nut 2004; HN7 - Crag Seed 2004; HS9 - Alyssa Seed 2004.

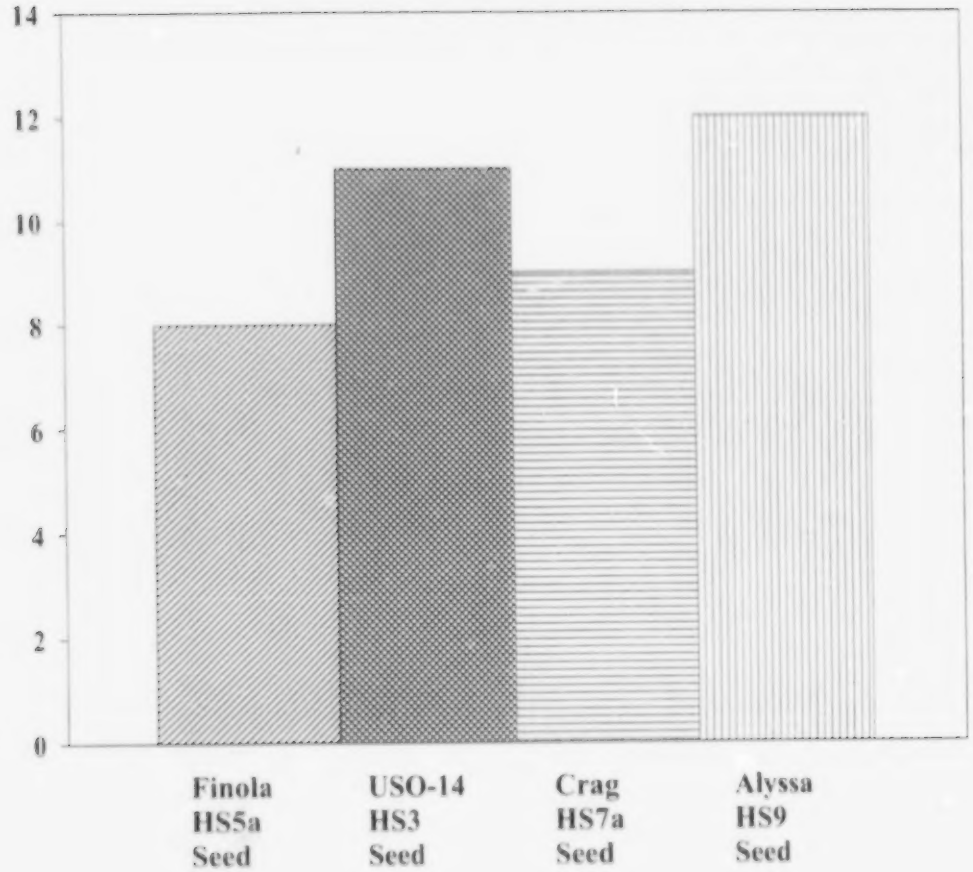

Fig 17. Presence of beta-carotene as provitamin A in selected hemp seeds.